PRELIMINARY SURVEY OF TOXIC SUBSTANCES

IN

THE DUWAMISH ESTUARY

Municipality of Metropolitan Seattle
Water Quality Planning Division

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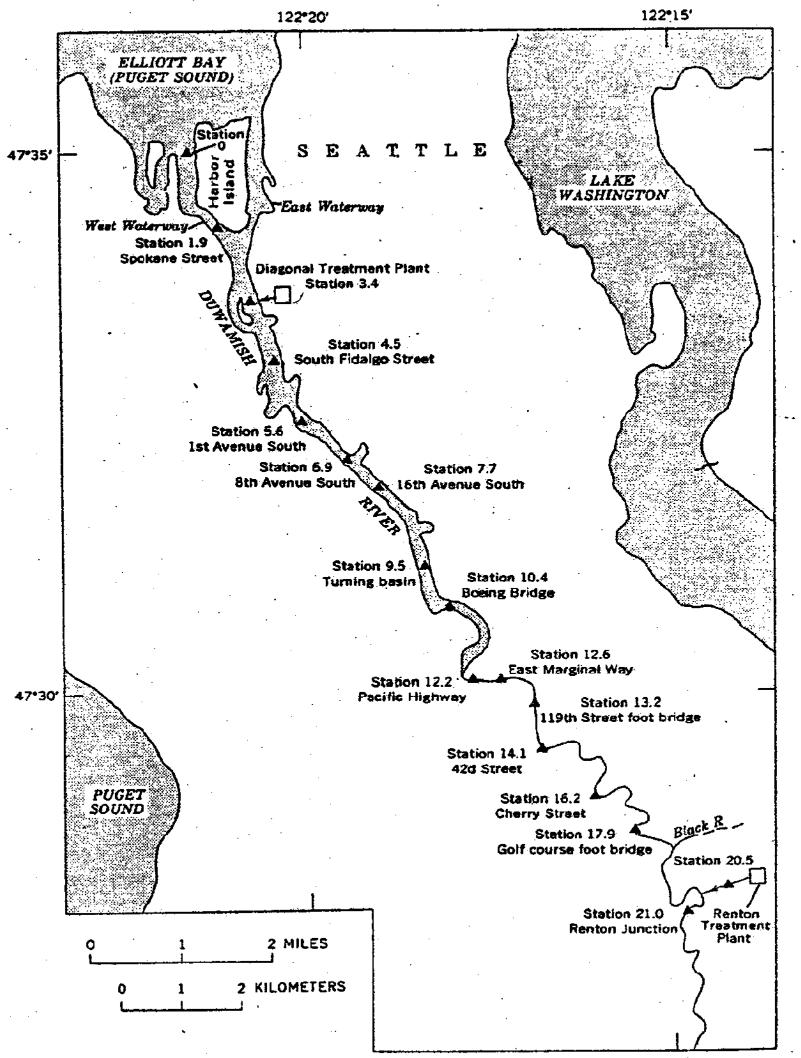
The Green-Duwamish River system has historically been central to the development of metropolitan Seattle and continues to be vital to the present and planned future economic development. Heavy use of the river for industrial and navigational purposes and for municipal waste disposal alongside its importance as a migratory zone for salmonid fish has made attention to water quality a necessity. Pollution of the river was first documented in 1948, and has been of concern to Metro since the agency was organized in 1958. In Metro's Areawide Water Quality Plan, the Duwamish is prioritized as the most polluted stream.

Currently there is a new awareness of the presence, or potential presence, in waterways such as the Duwamish of a large number of pollutants that are considered to be toxic. Some of the substances have toxic properties that are well known; knowledge of others is quite recent and not yet complete. However, the possibilities of present or future hazard are felt to be too great to ignore.

As a result of these kinds of concerns, which are reflected in an emphasis on toxicant programs at the federal level of government as well as at the local level, Metro is becoming involved in an analysis of the Duwamish River. Metro's intent is to look at a broad range of parameters to determine what potential toxicants are present in significant amounts, what the approximate levels of such pollution are, and what the probable sources are. The ultimate objective is to plan a program to reduce the entry of toxicants to the river.



Map showing a number of points on the Duwamish River, including those mentioned in this report. Station numbers indicated are in kilometers upstream from the river's mouth. (Map from Santos and Stoner, 1972.)

The first steps are to find out what is known and documented about toxic substances in the river and then to determine what additional information is needed to provide a reasonably complete picture of the occurence of the toxicants in the river.

In a short period of about three weeks we have attempted to survey the available literature pertaining to toxicants in the Duwamish. There is, of course, considerable general water quality data on the river and there is background information on the physical, chemical and biological functioning of the estuary. Information on toxic substances is much less plentiful; the only toxic substances reported for the river are polychlorinated biphenys (PCB), pesticides (DDT and related compounds), trace metals, and oil and grease. Data for these parameters is patchy. Heavy metals are anlayzed regularly at a number of stations on the river as part of Metro's water quality monitoring program, and there is historical data available as well. A general survey of Puget Sound, including the Duwamish, for PCB and pesticides was done in 1973-1974 by the University of Washington. Other studies have primarily been concerned with the 1974 PCB spill at Slip 1 or with the Corps of Engineers dredging programs, and these were restricted to certain sections of the estuary. There has been some data reported on combined sewer overflows in the area--both for the effluents and the sediments--and data is available on treatment plant effluents. There have been some reports of PCB and metals levels in Duwamish fish and other organisms. There is data that we're aware of but have not seen. There is undoubtedly data available that we're not aware of at this point, and we would welcome information about such items.

There is evidence that contaminants in the Duwamish may produce pathological effects on resident fish species. Fish from three areas in Puget Sound and from the Duwamish were studied, and a high proportion of Duwamish fish were diseased. Most of the liver disease and all of the fin erosion encountered in the study were in Duwamish fish. The fin disease was related to sediments in that fins normally in contact with the sediment were most often affected. In a laboratory study, two of thirty apparently healthy fish exposed to Duwamish sediment developed fin disease, while of thirty fish exposed to a control sediment none developed the disease. The liver disease in Duwamish fish was consistent with abnormalities shown in other studies to result from exposure to PCB and other chlorinated hydrocarbons. Furthermore, analysis of Duwamish fish and sediments for PCB indicated that Duwamish fish livers had about 40 times the concentration found in fish from the control area and the sediments had about 360 times the PCB in the control site sediments. In an EPA study of six Washington estuaries, measurable levels of PCB in fish were found only in the Duwamish.

WHAT THE EXISTING DATA REVEAL ABOUT LEVELS OF TOXICANTS IN THE RIVER.

Table 1 shows levels of toxic substances identified in the existing data for various reaches of the river. The most plentiful data available were PCB concentrations. The 1973-1974 data indicated a dramatic increase in sediment PCB in the downstream direction, as might be expected. Values for water were not available except in the lower reaches. Other chlorinated hydrocarbons (HC) show a similar gradient. The 1976 PCB data in the downstream reach were collected after the Slip 1 clean-up, and those in the up-stream reach were collected before the channel was dredged in that location. The levels of PCB shown for sediments are high, ranging between 11 and 6982 ppb. (parts per billion). By comparison, northern Puget Sound sediments were reported to range from 9-50 ppb. Levels in Duwamish estuary water are shown to range between 40 and 60 ppt. (parts per trillion) while Puget Sound water had concentrations of PCB from 1-7 ppt. Levels of PCB reported in the 1976 sediment data are much higher than the values reported for the same sections in 1973-1974. It is possible that this reflects the variability between localized sediments rather than a change over time.

Oil and grease is a broad category that includes many toxic substances not specifically identified. The few pieces of data available indicate much higher concentrations near Slip 1 than upstream at 16th Avenue.

Part of the metals data is for water and part for sediment. Levels in the water are of concern for aquatic life and for other uses of the water itself. Sediment levels, however, reflect the

Table 1. Levels of Toxicants Found in Duwamish River Water and Sediments: Data From Several Sources

PARAMETERS		DUWAMISH RIVER SECTIONS									
		1 (Mouth-Slip 1)		2 (Slip 1-16th Ave.)		3 (16th Ave. to E. Marginal Way)		4 (E. Marginal Way to Renton Junction		5 (Above Renton Junction)	
		Water	Sed.	Water	Sed.	Water	Sed.	Water	Sed.	Water	Sed.
1973-1974	PCB*	39-40	1,297	27-58	610		333		77		
	HC(DDT, etc.)		76.0		10.0		8.1		2.4		
	Oil & Grease										
	Iron		17,000-86,000		14,000-48,000		9,000-32,000				
	Mercury		.01-.25		.03-.21		.04-.06				
	Lead		0-28		0-73		9-32				
	Zinc		65-319		31-201		98-210				
	Nickel		11-35		11-38		24-27				
1976	PCB	6-9	3,000-50,000				11-6,982				
	HC										
	Oil & Grease	.2-.3	1,525-2,445				40-2,460				
	Cadmium[1]	<2	.8-9.9	4-16		4-5		4-8		4-6	
	Chromium[2]	6-28	18-27	8-15		8-14		8		8	
	Copper[2]	17-54	44-82	5-46		5-23		5-6		5	
	Iron	310-330	13,000-21,000								
	Mercury[1]	.4-.6	.2-.5	.2-2.3		.2-3.6		.2		.2	
	Lead[1]		60-274	40-200		40-200		20-200		20-200	
	Zinc[2]	4-19	126-3,270	6-38		5-20		5-50		5-10	
	Nickel[1]	35	1,700-4,000	20-40		20		20		20	

*PCB: Water values, ppt.; sediment values, ppb.
Oil & Grease: All values, ppm.
Metals: Water values, ppb.; sediment values, ppm.

1. Lowest reported values are at detection limit, used as minimum reportable value, and it is above the standard.
2. Lowest reported values are at detection limit, used as minimum reportable value, but it is below the standard.

effects of inputs over a period of time and are not subject to transitory concentrations in the same way the water is. The downstream trends of cadmium, chromium, and copper--based on water data--are for increasingly higher maximum levels. Iron shows the same kind of downstream increase in the sediment data. Mercury, nickel, lead and zinc don't show clear trends on the basis of these data. This is partly due to actual levels being lower than the detection limit of the analysis although in some cases the latter level was well above the standard. Such levels were reported as at the detection limit. Additionally, generalized atmospheric sources of lead may mask sources from runoff to obscure the upstream-downstream trend.

Acceptable levels (in water) of the parameters are presented in Table 2. In most instances the acceptable levels are EPA criteria. In some cases where the EPA criteria are not specific, levels have been selected by Metro staff based on literature related to local fish species. These selected values are noted by a footnote. In all cases the levels of PCB, HC, and oil and grease reported for water exceeded the acceptable levels. All values in water for cadmium, mercury, lead, iron and nickel exceeded the acceptable levels, but this is probably at least partly due to insensitivity of the analysis as discussed above. Copper levels exceeded the standard downstream of East Marginal Way and zinc was reported in excess above Slip 1 and above East Marginal Way.

Dissolved oxygen (DO) is not a toxicant, but is a basic parameter that indicates some types of degradation--organic pollution primarily--and, in part, suitability for aquatic life. The earlier

Table 2. Water Quality Standards for the Parameters Discussed[4]

Parameter	Standard
DO	5-6.5 ppm[1]
PCB	1 ppt[2]
HC (DDT, etc.)	1 ppt
Oil and Grease	none
Cadmium	0.2 ppb[3]
Chromium	0.05 ppm[3]
Copper	0.01 ppm
Iron	0.05 ppm
Lead	0.01 ppm
Mercury	0.05 ppb
Zinc	0.02 ppm
Nickel	2 ppb

1. Washington State standard
2. Parts per trillion
3. Standard derived from EPA guidelines, and based on requirements of local fish species.
4. Standards not otherwise identified are EPA criteria

historical references to pollution in the Duwamish are mostly related to low DO. Historically the lowest DO levels have been found in the bottom layer of water at the 16th Avenue Bridge during the low flow periods between August and November.

Table 3 shows the ranges of monthly minimum DO values for bottom waters at that station for the critical months of 1969-1976. While it isn't possible to see an improving trend in these data alone, the values do compare favorably with historical monthly mean values at the same station as seen in Table 4. This is an indication that dissolved oxygen conditions at 16th Avenue are better now than they were in the 1960's--perhaps influenced by closure of the Diagonal Avenue Treatment Plant--however an analysis of directly comparable data is necessary to state that with confidence. That data is available but was not obtained in time for inclusion here.

Summary

This limited collection of data permits several conclusions as to what we do and do not know about toxicants in the river.

(1) The section from the mouth up through the Slip 1 area is heavily contaminated with all the parameters.

(2) Levels of PCB and other HC in the sediment decline in the upstream direction, but we don't know about the levels in the water upstream.

(3) Levels of metals in upstream water are undoubtedly lower than at the mouth, but insensitivity of the metals analyses tends to obscure the upstream trends.

Table 3. Minimum Dissolved Oxygen Ranges in the Bottom Waters at 16th Avenue for August-November of 1969-1976

Year	Minimum DO Range, ppm
1969	1.3 - 2.6
1970	3.9 - 4.5
1971	3.7 - 4.5
1972	4.0 - 4.6
1973	4.2 - 4.7
1974	3.6 - 4.2
1975	3.8 - 5.2
1976	4.1 - 5.0

Table 4. Historical Mean Dissolved Oxygen in the Bottom Waters at 16th Avenue for Late Summer-Fall Months

Year	Mean DO Range, ppm (approx.)
1949	4.5 - 5.5
1956	5 - 6
1962	4.5 - 5
1963	4 - 6
1964	4.5 - 6
1965	3 - 4.5
1966	2.5 - 5

(4) Levels of metals in upstream sediments aren't known.

(5) We don't know whether there are significant sources of contamination above Renton.

(6) We don't know what "background" levels look like upstream of all industrial development.

SUGGESTED DIRECTIONS FOR FURTHER ANALYSIS

The data cited, while limited in scope and quantity, are evidence of very high levels of some toxicants in both the sediments and the water. There is insufficient information however to identify more than one or two general "hot spot" areas or any probable sources. It's known that the major industries discharge wastes (except cooling waters) to the West Point Treatment Plant. The effluent from the Renton Treatment Plant is not thought to be a major contribution, at least of PCB. Rough calculations have indicated - based on the average discharge of PCB from Renton - that over a ten year period the total discharge from the plant would amount to less than 10 percent of the estimated total burden of PCB in the estuary sediments. Before recommending a specific program for tighter control of toxicants, there is an obvious need to obtain a more comprehensive set of data with attention to the following points:

(1) Only a few parameters have been studied; we need to make sure we're aware of the identity of the major toxicants in the system.

(2) Analyses of sediments and water should be done at strategic intervals from the mouth to a point above the Renton Treatment Plant. Data collected from a point well above all industrial development could provide "background" values.

(3) A comprehensive set of toxicant data from storm sewer discharges to the river should be collected.

(4) The contribution of the Renton Treatment Plant should be further evaluated.

(5) The dissolved oxygen data should be analyzed to determine significant trends at several stations.

A program to define the problems in the river might include the following elements:

1. A broad screening (laboratory analyses) to indicate toxicants present in significant concentrations in sediments and water at the following general locations:
   - Mouth
   - At or just below Slip 1
   - 16th Avenue Bridge
   - Above the Renton Treatment Plant
   - Selected CSO effluents
   - Renton Treatment Plant effluent (It will already have been screened.)
2. Based on the parameters identified by the screenings, a more detailed study:
   - A fairly large number of sediment samples from locations chosen to better define the areas of heaviest concentration and provide "background" values for comparison.
   - Periodic water samples from fewer stations than the sediments but over an area extending from the mouth to a point above all industrial development.
   - Aggressive sampling of a more complete array of storm sewer effluents as well as sediments from outfall areas.
   - Analysis of the contribution from the Renton Plant.

Existing programs and data can provide a portion of the required information. For example, an imminent Metro study will include sampling Duwamish sediments at a number of locations. The analysis will include heavy metals, PCB, and pesticides. The usefulness of existing data will depend in part upon which toxicants must be considered.

NOTE: Sources of data used are indicated on the list of references. Additional unpublished Metro data has been used.

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*Indicates a source of data used in this report.

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